CARCASS AND PALATABILITY CHARACTERISTICS OF CATTLE OF DIFFERENT AGES AND BREEDING

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SUMMARY

A study was conducted to determine the effect of selection method, age, and sire on carcass, palatability, and chemical characteristics of beef cattle. Over a four-year period, sixty steer calves were chosen from each of two herds represented in this study. One herd had its sires and replacement females selected at random and the other by use of a selection index.

Sixteen calves from each herd were creep-fed while nursing dams. They were slaughtered at approximately 10 months old (calves). The remaining calves were maintained on their dams until weaned in the late fall. Sixteen additional calves from each herd were wintered on a roughage diet, grazed on pasture until the first day of July, then placed on a finishing ration until slaughtered at approximately 22 months old (steers). The data were analyzed within age groups to test for sire and selection method differences and were then pooled for testing differences between age groups. In addition, simple correlation coefficients were computed between selected variables.

Selection method did not significantly affect any carcass characteristics considered in this study. Selection criteria or selection pressure were evidently inadequate to produce differences. The steer group was significantly superior to the calves for carcass weight, dressing per cent, marbling, carcass grade, and rib eye area. These differences are attributable to the large differences in age and weight between the two groups. Rib eye area per 100 pounds carcass weight was significantly higher and external fat thickness significantly less for the younger age group.

Sires significantly affected carcass weight, rib eye area, fat thickness per 100 pounds carcass weight, and rib eye area per 100 pounds carcass weight for steer carcasses. Dressing per cent, conformation, marbling, and rib eye area of calf carcasses were significantly affected by sires. Lack of agreement between age groups for sire differences in carcass characteristics could be due to sire groups differing in growth patterns.

Random herd steer carcasses produced steaks which were more tender as measured by the taste panel than steaks from selected herd steer carcasses. Per cent ether extract was significantly higher for steaks from selected herd steer carcasses, this difference being substantiated by higher marbling levels for the same group of carcasses.

Juiciness, flavor, and overall acceptability were significantly higher for steaks from steer carcasses. Warner-Bratzler shear values indicated steaks from steer carcasses were significantly more tender than steaks from calf carcasses. Although tenderness ratings were non-significant between age groups, higher ratings for steaks from steer carcasses substanti-

ated Warner-Bratzler shear values. Per cent ether extract was significantly higher for steaks from steer carcasses and per cent moisture was higher in steaks from calf carcasses, these differences being attributable to marbling differences between the age groups.

Sires significantly influenced juiciness and per cent ether extract of steaks from both age groups and Warner-Bratzler shear values and per cent protein of steaks from calf carcasses.

CARCASS AND PALATABILITY CHARACTERISTICS OF CATTLE OF DIFFERENT AGES AND BREEDING

JAMES L. McBEE, JR., DAVID H. BOWERS, AND C. J. CUNNINGHAM

THE BEEF CATTLE INDUSTRY in West Virginia is characterized by the cow-calf system requiring a large amount of roughage. Sale of feeder calves is the main source of revenue for the beef industry.

The meat packing industry in West Virginia is small and procures a arge percentage of its beef from other areas. High quality slaughter attle and carcass beef are the items most often purchased outside the state.

Meat packers and retailers currently desire a beef carcass which has a high ratio of lean to fat and satisfactory eating quality. Of the three riteria of eating quality—tenderness, juiciness, and flavor—tenderness is onsidered the most important. Tenderness is influenced by a multitude of factors, with age being one of the more important, as indicated by the J.S.D.A. grading system.

Production of lightweight beef from calves less than one year old, hat are creep-fed while still nursing their dams, may present an opporunity for cow-calf operators to increase production of high quality beef and still provide the meat packer with cattle having a high ratio of lean o fat and satisfactory eating quality.

The purpose of this study was to compare the carcass traits, palatability characteristics, and chemical composition of calves creep-fed while nursing their dams and slaughtered at approximately 10 months old with omparable cattle born at the same time, but weaned, wintered, placed in he feedlot the following summer and fed to normal slaughter age of approximately 22 months. The effect of sire, year, and herd replacement election criteria on carcass traits and palatability characteristics was also nvestigated.

LITERATURE REVIEW

EFFECT OF YEAR ON CARCASS AND PALATABILITY CHARACTERISTICS

Daillard *et al.* (1964) reported significant year effects on most carcass measurements. Experimental results have shown average daily gain, slaughter weight, slaughter grade, carcass weight, dressing per cent, carcass grade, marbling score, fat thickness, and rib eye area vary significantly from year to year (Cole *et al.*, 1963). Ramsey *et al.* (1963) showed significant year effects on tenderness, juiciness, flavor, and shear force values.

EFFECT OF SIRE ON CARCASS AND PALATABILITY CHARACTERISTICS

An investigation by Knapp and Nordskog (1946) involving 177 steer calves from 23 sires revealed heritabilities of 84, 1, and 69 per cent for carcass grade, dressing per cent, and rib eye area, respectively. Zinn (1964), in a review of literature, combined heritability estimates of other researchers and obtained the following averages: carcass grade, 44 per cent; carcass weight per day of age, 25 per cent; rib eye area, 63 per cent; fat thickness, 35 per cent; and marbling, 29 per cent. Bradley *et al.* (1966), conducted an investigation which showed sires significantly affected carcass weight per day of age, rib eye area, rib eye area per 100 kg. carcass weight, and fat thickness. Differences in carcass conformation, marbling score, and carcass grade were not significant. Jones *et al.* (1963) found distinct sire differences in tenderness, juiciness, and flavor when they studied five sire groups, each containing five or six animals slaughtered at 1,000 pounds live weight.

EFFECT OF ANIMAL AGE ON CARCASS AND PALATABILITY CHARACTERISTICS

Henrickson and Moore (1965) compared 40 steers and females of four age groups (6, 18, 42, and 90 months). Tenderness, determined by a taste panel, was significantly different for age groups, decreasing as age increased. Warner-Bratzler shear values indicated 6-month old cattle were less tender than 18-month old but more tender than 42- and 90-month old cattle. No differences in flavor and juiciness due to age were detected. Field *et al.* (1966) conducted a study involving 84 steers and females ranging in age from 300 to 699 days. Taste panel results showed older cattle were superior to younger cattle in tenderness, juiciness, and flavor. Younger cattle were more tender than older cattle as determined

by Warner-Bratzler shear values. Least squares estimates indicated age had a non-significant effect on tenderness, juiciness, flavor, and shear values when marbling was held constant. Romans *et al.* (1965) conducted a study involving 80 beef ribs from carcasses of four maturity levels (A, B, C and D). Taste panel results indicated ribs of D maturity carcasses were significantly less tender than ribs of the older maturities, with no significant differences among the other maturities.

EXPERIMENTAL PROCEDURE

Two cow herds were maintained at the Reymann Memorial Farms, Wardensville, West Virginia, a sub-station of the West Virginia University Agricultural Experiment Station. The experiment began in the spring of 1962 and was terminated in the winter of 1966.

The two herds at this sub-station have been closed since 1956. In one, designated the random herd, the sires and replacement females were selected at random from each year's production. In the other, designated the selected herd, the sires and replacement females were selected from the annual calf production by use of a selection index based on grade and gain.

The females from each herd were divided into two groups, each group being exposed to a single sire from May through July in order that calving would occur in February, March, and April. Replacement females and sires were selected in August. The male calves which remained after selection of replacement sires were castrated and divided into sire groups. From each sire group the eight highest indexing steer calves were selected and randomly divided into two groups of four each—one group to be slaughtered when approximately 10 months old and the other to be slaughtered when approximately 22 months old.

The calves to be slaughtered at about 10 months were maintained on their dams and self-fed in a creep from August until December.

The steers to be slaughtered at 22 months were weaned in October and wintered on a ration producing an average daily gain of one pound per day. When pasture became available in the spring, they were grazed until placed in the feed lot about July 1. The steers were placed on a finishing ration and fed until slaughtered in December.

The cattle were slaughtered at a commercial packing plant, where carcass data were collected and a short loin purchased for palatability, mechanical, and chemical evaluation.

CARCASS EVALUATION

All animals were weighed and graded at the farm before shipment to the packing plant and weighed upon arrival at the plant.

Each carcass was ribbed, and maturity, marbling level, conformation grade, and overall carcass grade were determined according to U.S.D.A. Official Standards for Grades of Carcass Beef (1965). Numerical codes for statistical purposes were 1 for A maturity, 2 for B maturity, and marbling ranged from extremely abundant = 11 to practically devoid = 1.

Hot carcass weights were obtained immediately after slaughter and cold carcass weight calculated by subtracting cooler shrink (2.5 per cent of the hot carcass weight). Dressing per cent was calculated from the cold carcass weight and plant live weight. External fat thickness and rib eye area measurements were obtained according to the procedures outlined by Naumann (1952). Fat thickness and rib eye area per 100 pounds carcass weight were calculated.

TREATMENT OF SHORT LOINS

The short loins were cut through the center of the twelfth rib and four 3.8 cm. steaks removed and coded A through D, beginning at the anterior end. The carcass number was recorded on each steak, all were wrapped in laminated freezer paper and frozen at -20° C until tested.

COOKING PROCEDURE AND PALATABILITY TESTS

Cooking procedure and palatability trials were conducted according to the method outlined by Wiles (1966).

CHEMICAL ANALYSIS

The sample preparation was conducted as outlined by Wiles (1966) and the analyses for moisture, ether extract, and protein were made according to the procedures of A.O.A.C. (1960).

STATISTICAL ANALYSIS OF DATA

There appeared to be a linear relationship between year of birth and the other variables in this study, therefore analysis of covariance was used to correct this source of variability. The mathematical model for the combined age data was assumed to be:

$$Y_{ijk} = H_i + S_{ij} + F_k + HF_{ik} + SF_{ijk} + b(X-\mu_x) + e_{ijk}$$

where:

Y_{ijk} = the measurement for the *k* th steer from *j* th sire in the *i* th herd

H_i = the average effect of *i* th herd

S_{ij} = the average effect of *j* th sire in *i* th herd

F_k = the average effect due to *k* th age of steer

HF_{ik} = the interaction between the *i* th herd and the *k* th age of steer

SF_{ijk} = the interaction between the *j* th sire in *i* th herd and the *k* th age of steer

b = the regression of Y on X

X = the year in which the calf was born

μ_x = the mean of year effect on all steers represented in this study

e_{ijk} = the random error which is assumed to be for all *i*, *j*, and *k* combinations.

The mathematical model for the within ages data was assumed to be:

$$Y_{ij} = H_i + S_{ij} + b(X - \mu_x) + e_{ij}$$

where:

Y_{ij} = measurement for *j* th sire in the *i* th herd

H_i = the average effect of *i* th herd

S_{ij} = the average effect of *j* th sire in *i* th herd

b = regression of Y on X

X = the year in which the calf was born

μ_x = the mean of year effect on all steers represented in this study

e_{ij} = the random error which is assumed to be for all *i* and *j* combinations.

Duncan's New Multiple Range Test (DNMRT) was run on all of the covariate sire means at the $P < .05$ level to detect sire differences not produced by the analysis of covariance.

Simple correlation analyses were run between 11 selected variables which were measured or evaluated in this study.

RESULTS AND DISCUSSION

Herd by age and sire by age interactions were usually significant when age was included as a source of variation in the analysis of covariance. This indicated it was necessary to remove age as a source of variation by computing the analysis of covariance within the age groups. Results of both analyses are presented in the tables and text, but discussion of herd differences is limited to the results of analysis within age groups.

Analysis of covariance was used to test the average difference between sires, while DNMRT was used to detect differences between individual pairs of sires. In general, one would expect DNMRT to show differences between pairs of sires that might not be apparent through use of analysis of covariance. Ordinarily, analysis of covariance would not show significant differences when DNMRT failed to detect differences between pairs of sires. However, one sire had only one progeny in the older age group, and when this sire was on the extreme of the arranged means, analysis of covariance would detect significant differences where DNMRT would fail to do so. All DNMRT were conducted at $P<.05$ level of probability. Except for the above instance, sire differences are discussed using DNMRT results.

CARCASS CHARACTERISTICS

Results of combined age analysis of covariance did not show significant herd differences for birth weight, final farm grade, drift, age in days, carcass conformation, marbling, maturity, rib eye area, and external fat thickness (Table 1). Final farm weight was significantly ($P<.05$) greater for the random herd. The random herd was significantly ($P<.01$) superior to the selected herd for plant weight, hot carcass weight, cold carcass weight, dressing per cent, and carcass grade as shown by results of combined age analysis of covariance (Table 1).

Within age analysis of covariance results did not reveal significant herd differences for any variable studied (Table 1). Lack of differences between herds indicated selection did not occur or the selection index was unable to produce significant differences. Herd history shows a considerable number of replacement females was required to replace infertile brood cows and, on one occasion, a selected sire of low fertility was replaced by a sire inferior to the infertile sire. These occurrences made improvement by selection difficult. The random and selected herds were originally obtained by randomly dividing a single herd and managing the two groups as described in the experimental procedure. With a similar genetic background, improvement by selection in one group in a short period of time would be difficult to detect.

Results of combined age analysis of covariance detected significantly ($P<.01$) higher hot and cold carcass weight, dressing per cent, and carcass grade for steer carcasses (Table 1). Steers also had significantly ($P<.01$) more marbling, external fat, and rib eye area. Calf carcasses had a significantly ($P<.01$) larger rib eye area per 100 pounds carcass weight. Results did not show significant differences between steers and calves for conformation, maturity, or external fat thickness per 100 pounds carcass weight.

TABLE 1

Combined Age and Within Age Covariate Means of Carcass Characteristics For Herd and Age Groups

Variable	Combined Age Means				Within Age Means			
	Herd		Age		Calves		Steers	
	Selected	Random	Calves	Steers	Selected	Random	Selected	Random
Birth Weight, lb.	62.19	64.84	65.67	61.41	63.09	67.86	59.81	63.39
Final Farm Weight, lb.	753.15	763.84*	556.72	950.74**	557.37	566.22	932.54	957.65
Final Farm Grade	10.42	9.79	9.37	10.74**	9.69	8.93	10.83	10.71
Plant Weight, lb.	729.73	737.77**	536.98	920.18**	539.58	548.16	904.70	930.22
Drift, lb.	25.11	29.37	24.12	30.62	22.41	24.74	27.79	27.69
Age, days	468.82	464.35	292.87	640.28**	293.72	292.18	640.96	641.18
Hot Carcass Weight, lb.	428.61	434.55**	304.89	551.41**	307.73	311.24	542.33	555.01
Cold Carcass Weight, lb.	416.12	423.37**	295.32	537.45**	294.26	303.49	528.85	541.16
Dressing Per Cent	56.83	56.99**	55.27	58.37**	55.48	55.45	58.46	58.12
Conformation	10.64	10.62	9.71	11.45	9.82	9.70	11.48	11.57
Marbling	2.70	2.74	1.87	3.52**	2.06	1.72	3.40	3.68
Maturity	1.05	1.05	1.00	1.12	1.00	1.00	1.07	1.11
Carcass Grade	9.97	10.14**	9.17	10.82**	9.06	9.21	10.87	10.94
External Fat Thickness, in.	0.40**	0.39	0.24	0.53**	0.25	0.23	0.53	0.52
Rib Eye Area, in.²	9.61	9.51	8.23	10.83**	8.17	8.24	10.82	10.75
External Fat Thickness, in. 100 lb.	0.10	0.09	0.09	0.10	0.10	0.08	0.10	0.10
Rib Eye Area, in.² 100 lb.	2.43	2.39	2.81**	2.03	2.79	2.78	2.05	2.00

* P .05
** P .01

Significantly higher hot and cold carcass weights for steer carcasses were expected due to large differences in age. Higher marbling levels and more external fat for steers are comparable to the results of a study by Callow (1947). Steer carcasses graded sufficiently higher than calf carcasses, attributable to significantly higher marbling levels and higher conformation scores. A significantly larger rib eye area for steers and a significantly larger rib eye area per 100 pounds carcass weight for calves agrees with the results of Miller *et al.* (1965). Their work showed that as carcass weight increased rib eye area increased and rib eye area per 100 pounds carcass weight decreased.

Non-significant sire differences were found for all variables studied except animal age when tested by combined age analysis of covariance (Table 2). DNMRT of combined age covariate sire means showed significant ($P < .05$) sire differences for birth weight, final farm weight, final farm grade, plant weight, age in days, hot and cold carcass weights, and rib eye area per 100 pounds carcass weight.

Within age analysis of covariance results revealed significant ($P < .05$) sire effects on final farm grade, drift, age in days, carcass conformation, and rib eye area of calves. Results for steers disclosed significant differences in birth weight, final farm weight, plant weight, drift, age in days, hot and cold carcass weights, and rib eye area per 100 pounds carcass weight between sire groups.

DNMRT detected significant sire differences in calves for birth weight, final farm grade, drift, age in days, dressing per cent, conformation, marbling, and rib eye area. Significant sire differences in steers were indicated by DNMRT for birth weight, final farm weight, final farm grade, plant weight, drift, age in days, hot and cold carcass weights, maturity, rib eye area, and fat thickness per 100 pounds carcass weight.

These findings substantiate those of other workers previously referenced which indicate that growth and carcass traits are heritable and afford opportunity for improvement.

TASTE PANEL AND PROXIMATE ANALYSIS CHARACTERISTICS

Tenderness, flavor, and overall acceptability ratings were significantly greater for steaks from random herd carcasses as revealed by combined age analysis of covariance (Table 3). Steaks from selected herd carcasses had significantly lower Warner-Bratzler shear values. Random herd carcasses produced steaks significantly higher in per cent ether extract, significantly lower in per cent moisture, and virtually the same protein content as selected herd carcasses.

Steaks from steer carcasses had significantly higher juiciness, flavor, and overall acceptability ratings as shown by combined age analysis of

TABLE 2

Analysis of Covariance and Duncan's New Multiple Range Test of Carcass Characteristics For Sire Means

Variable	Combined Age Means		Within Age Means			
			Calves		Steers	
	Covariate	DNMRT	Covariate	DNMRT	Covariate	DNMRT
Birth Weight, lb.	N.S.	0.05	N.S.	0.05	0.05	0.05
Final Farm Weight, lb.	N.S.	0.05	N.S.	N.S.	0.01	0.05
Final Farm Grade	N.S.	0.05	0.05	0.05	N.S.	0.05
Plant Weight, lb.	N.S.	0.05	N.S.	N.S.	0.01	0.05
Drift, lb.	N.S.	N.S.	0.01	0.05	0.01	0.05
Age, days	0.01	0.05	0.01	0.05	0.01	0.05
Hot Carcass Weight, lb.	N.S.	0.05	N.S.	N.S.	0.01	0.05
Cold Carcass Weight, lb.	N.S.	0.05	N.S.	N.S.	0.01	0.05
Dressing Per Cent	N.S.	N.S.	N.S.	0.05	N.S.	N.S.
Conformation	N.S.	N.S.	0.05	0.05	N.S.	N.S.
Marbling	N.S.	N.S.	N.S.	0.05	N.S.	N.S.
Maturity	N.S.	N.S.	N.S.	N.S.	N.S.	0.05
Carcass Grade	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
External Fat Thickness, in.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Rib Eye Area, in.^{2}	N.S.	N.S.	0.05	0.05	N.S.	0.05
External Fat Thickness, in./100 lb.	N.S.	N.S.	N.S.	N.S.	N.S.	0.05
Rib Eye Area, in.^{2}/100 lb.	N.S.	0.05	N.S.	N.S.	0.05	N.S.

N.S. Not significant
0.05 – Significant at 0.05 level of probability
0.01 – Significant at 0.01 level of probability

TABLE 3

Combined Age and Within Age Covariate Means of Taste Panel and Proximate Analysis Characteristics for Herd and Age Groups

Variable	Combined Age Means				Within Age Means			
	Herd		Age		Calves		Steers	
	Selected	Random	Calves	Steers	Selected	Random	Selected	Random
Panel Tenderness	4.64	4.92**	4.45	5.06	4.40	4.54	4.90	5.29*
Panel Juiciness	4.67	4.76	4.47	4.94*	4.55	4.37	4.85	4.91
Panel Flavor	4.89	5.00**	4.68	5.18**	4.66	4.75	5.15	5.22
Panel Overall Acceptability	4.80	4.89**	4.60	5.08*	4.61	4.57	5.03	5.19
Warner-Bratzler Shear Force, lbs.	20.48	20.60**	22.76**	18.92	22.20	22.80	19.04	19.97
Per Cent Ether Extract	2.69	2.89**	1.41	4.00**	1.63*	1.27	3.80	4.28
Per Cent Protein	21.79	21.88**	21.84	21.76	21.78	21.90	21.75	21.90
Per Cent Moisture	73.93**	73.72	74.87**	72.94	74.83	74.85	73.07	72.76

* — $P < .05$
** — $P < .01$

covariance, as well as significantly lower Warner-Bratzler shear values, indicating more acceptable tenderness. Combined age analysis of covariance results disclosed that steaks from steer carcasses contained significantly higher per cent ether extract and those from calves contained significantly higher per cent moisture, while per cent protein did not differ significantly.

Results of combined age analysis of covariance did not reveal significant sire differences in taste panel characteristics or Warner-Bratzler shear values. DNMRT of combined age sire means showed significant differences for Warner-Bratzler shear values, but not for taste panel ratings (Table 4).

Proximate analysis characteristics were not influenced by sires, as indicated by results of combined age analysis of covariance. DNMRT revealed significant sire differences in per cent moisture only (Table 4).

Within age analysis of covariance results for taste panel ratings, Warner-Bratzler shear values, and chemical analyses of steaks from calf and steer carcasses did not show significant sire differences. DNMRT results revealed significant sire differences in juiciness scores, Warner-Bratzler shear values, per cent ether extract, and per cent protein of steaks from calf carcasses, and in per cent ether extract of steaks from steer carcasses.

RELATIONSHIPS AMONG CHEMICAL, PALATABILITY, AND CARCASS CHARACTERISTICS

Correlation coefficients between 44 selected pairs of variables are presented in Table 5.

Carcass grade was significantly correlated with dressing per cent, farm grade, and fat thickness. Since carcass grade, dressing per cent, farm grade, and fat thickness were significantly higher for steers, these positive relationships probably are a result of differences in fat thickness between the two age groups.

It appears the correlation coefficients in Table 5 were greatly influenced by one factor—age at slaughter. The relationships between per cent ether extract and marbling, carcass grade, age at slaughter, fat thickness and rib eye area were the same in sign and approximately the same in magnitude. Sensory characteristics, Warner-Bratzler shear values, and the remainder of the proximate analysis characteristics show the same relationship. Marbling levels, carcass grade, fat thickness, rib eye area, and age at slaughter were significantly higher for steer carcasses and were highly correlated with each other.

Per cent ether extract was directly related to marbling levels, carcass grade, age at slaughter, fat thickness, and rib eye area. Per cent moisture

TABLE 4

Analysis of Covariance and Duncan's New Multiple Range Test of Taste and Proximate Analysis Characteristics for Sire Means

Variable	Combined Age Means		Within Age Means			
			Calves		Steers	
	Covariate	DNMRT	Covariate	DNMRT	Covariate	DNMRT
Panel Tenderness	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Panel Juiciness	N.S.	N.S.	N.S	0.05	0.05	N.S.
Panel Flavor	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Panel Overall Acceptability	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
Warner-Bratzler Shear Force, lb.	N.S.	0.05	N.S.	0.05	N.S.	N.S.
Per Cent Ether Extract	N.S.	N.S.	N.S.	0.05	N.S.	0.05
Per Cent Protein	N.S.	N.S.	N.S.	0.05	N.S.	N.S.
Per Cent Moisture	N.S.	0.05	N.S.	N.S.	N.S.	N.S.

N.S. = Not significant
0.05 = Significant at P<.05
0.01 = Significant at P<.01

as inversely related to marbling levels, carcass grade, age at slaughter, at thickness, and rib eye area. The inverse relationship between per cent noisture and per cent ether extract can be attributed to marbling displacing muscle cells containing a much higher per cent moisture, since narbling was highly correlated with other carcass variables.

Significant, but low correlations were computed between taste panel haracteristics and marbling levels.

Taste panel ratings were significantly related to carcass grade, age at laughter, fat thickness, and rib eye area in a positive manner. Warner-Bratzler shear values were negatively correlated with marbling levels, arcass grade, age at slaughter, fat thickness, and rib eye area. These reults coincide with the correlations between taste panel tenderness ratings nd the above five variables. Warner-Bratzler shear value correlation coefficients were larger in magnitude than were panel tenderness correlation coefficients.

TABLE 5

Correlation Coefficients for Proximate Analysis, Palatability, Carcass, and Growth Variables

Variable (1)	Variable (2)	r
Birth Weight	Final Farm Weight	−0.06
Marbling	Carcass Grade	0.80**
Marbling	Rib Eye Area	0.63**
Marbling	External Fat Thickness	0.70**
Marbling	Per Cent Ether Extract	0.78**
Marbling	Per Cent Protein	−0.02
Marbling	Per Cent Moisture	−0.75**
Marbling	Panel Tenderness	0.31**
Marbling	Panel Juiciness	0.24**
Marbling	Panel Flavor	0.11**
Marbling	Panel Overall Acceptability	0.29**
Marbling	Warner-Bratzler Shear Values	−0.42**
Carcass Grade	Rib Eye Area	0.57**
Carcass Grade	External Fat Thickness	0.66**
Carcass Grade	Dressing Per Cent	0.54**
Carcass Grade	Per Cent Ether Extract	0.67**
Carcass Grade	Per Cent Protein	0.00
Carcass Grade	Per Cent Moisture	−0.70**
Carcass Grade	Panel Tenderness	0.34**
Carcass Grade	Panel Juiciness	0.27**
Carcass Grade	Panel Flavor	0.11**
Carcass Grade	Panel Overall Acceptability	0.26**

(Continued on next page)

Table 5 (continued)

Variable (1)	Variable (2)	r
Carcass Grade	Warner-Bratzler Shear Values	−0.46**
Age at Slaughter	Marbling	0.69**
Age at Slaughter	Carcass Grade	0.54**
Age at Slaughter	Rib Eye Area	0.79**
Age at Slaughter	External Fat Thickness	0.70**
Age at Slaughter	Per Cent Ether Extract	0.71**
Age at Slaughter	Per Cent Protein	−0.01
Age at Slaughter	Per Cent Moisture	−0.67**
Age at Slaughter	Panel Tenderness	0.36**
Age at Slaughter	Panel Juiciness	0.33**
Age at Slaughter	Panel Flavor	0.45**
Age at Slaughter	Panel Overall Acceptability	0.41**
Age at Slaughter	Warner-Bratzler Shear Values	−0.42**
Fat Thickness	Per Cent Ether Extract	0.78**
Fat Thickness	Per Cent Protein	0.05
Fat Thickness	Per Cent Moisture	−0.77**
Fat Thickness	Panel Tenderness	0.31**
Fat Thickness	Panel Juiciness	0.26**
Fat Thickness	Panel Flavor	0.42**
Fat Thickness	Panel Overall Acceptability	0.35**
Fat Thickness	Warner-Bratzler Shear Values	−0.51**
Rib Eye Area	External Fat Thickness	0.60**
Rib Eye Area	Per Cent Ether Extract	0.64**
Rib Eye Area	Per Cent Protein	0.07
Rib Eye Area	Per Cent Moisture	−0.61**
Rib Eye Area	Panel Tenderness	0.31**
Rib Eye Area	Panel Juiciness	0.29**
Rib Eye Area	Panel Flavor	0.38**
Rib Eye Area	Panel Overall Acceptability	0.34**
Rib Eye Area	Warner-Bratzler Shear Values	−0.43**
Final Farm Grade	Carcass Grade	0.48**

*P<.05
**P<.01

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